



sentinel-2

Sentinels for Agricultural monitoring – the case of irrigation

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European Space Agency

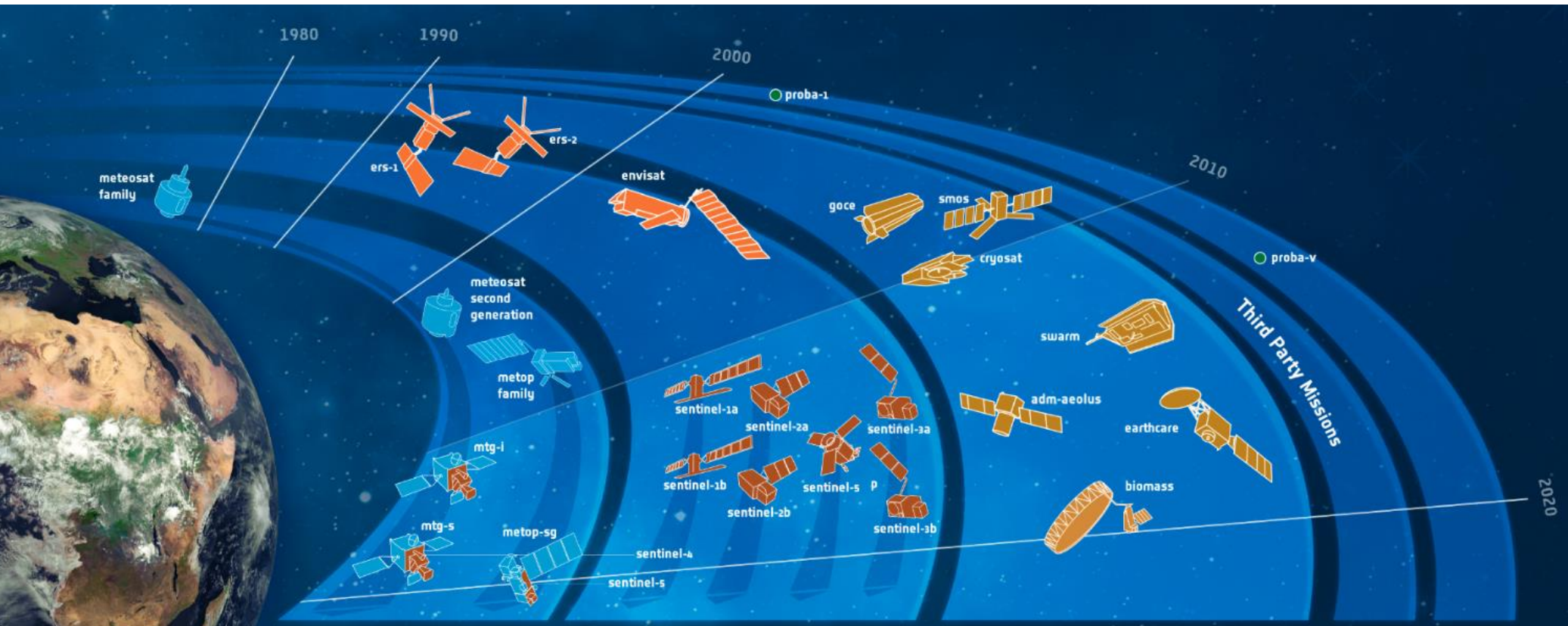
The ESA EO Programme



Scientific: Earth Explorer Missions

Operational: Copernicus Sentinel Missions

Operational: Meteorological Missions



Meteorological

Sentinels

Explorers

Sentinels – New Era of Observations

EU-ESA Copernicus Space Programme



Long-term Continuity & Access to Earth Observation data

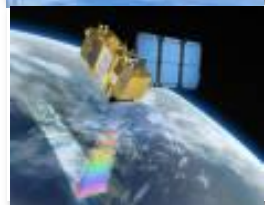
- Free and open data policy*



Sentinel 1 – SAR imaging

All weather, day/night application e.g.
water bodies, wetlands

2015 & 2016



Sentinel 2 – Multi-spectral

Land applications
Continuity of data

2015 & 2016



Sentinel 3 – Ocean and coastal monitoring
**ocean vegetation, land/sea
ice, bathymetry, lake water quality**

2015 & 2017



OPERATIONAL

* Joint EU/ESA Data Policy Principles adopted by ESA member states in Sep '09, EU announced in Nov. 2013

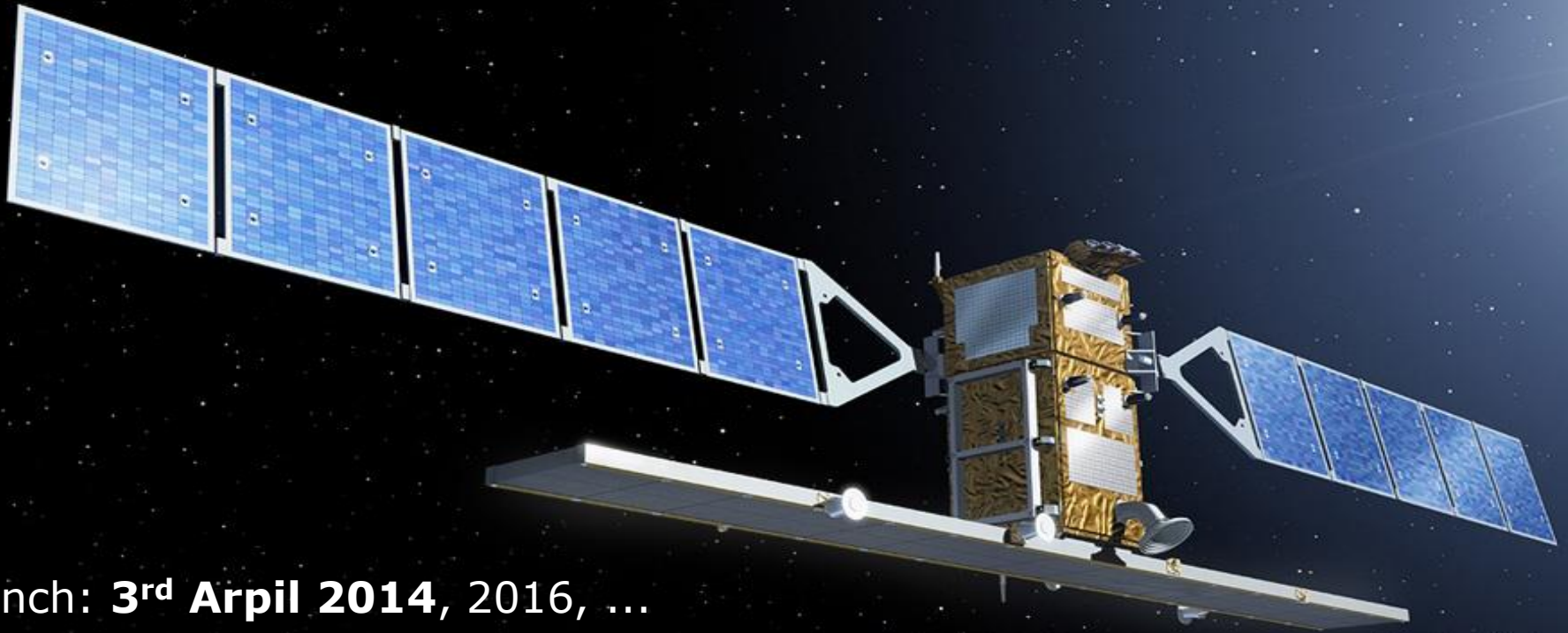
Sentinel contribution to GEOGLAM

Primary missions for all Targets Products



Req#	Spatial Resolution	Spectral Range	Effective observ. frequency (cloud free)*	Sample Type	Field Size	Target Products						
						Crop Mask	Crop Type Area and Growing Calendar	Crop Condition Indicators	Crop Yield	Crop Biophysical Variables	Environ. Variables	Ag Practices / Cropping Systems
Coarse Resolution Sampling (>100m)												
1	500 - 2000 m	thermal IR + optical	Daily	Wall-to-Wall	All			X				
2	100-500 m	optical + SWIR	2 to 5 per week	Cropland Extent	All	X	X	X	L	L		L
3	5-50 km	microwave	Daily	Cropland Extent	All			X	X	SMOS	X	
Moderate Resolution Sampling (10 to 100m)												
4	10-70m	optical + SWIR + TIR	Monthly (min 2 out of season + 3 in season). Required every 1-3 years.	Cropland Extent	All	X	L/M			Sentinel-2		X
5	10-70m	optical + SWIR + TIR	Weekly (min. 1 per 16 days)	Sample	All	X	X	X	X	Sentinel-2	X	X
6	10-100m	SAR	Weekly (min. 1 per 2 weeks)	Cropland Extent of persistant cloudy areas/Rice	All	X	X	X	X	Sentinel-1	X	X

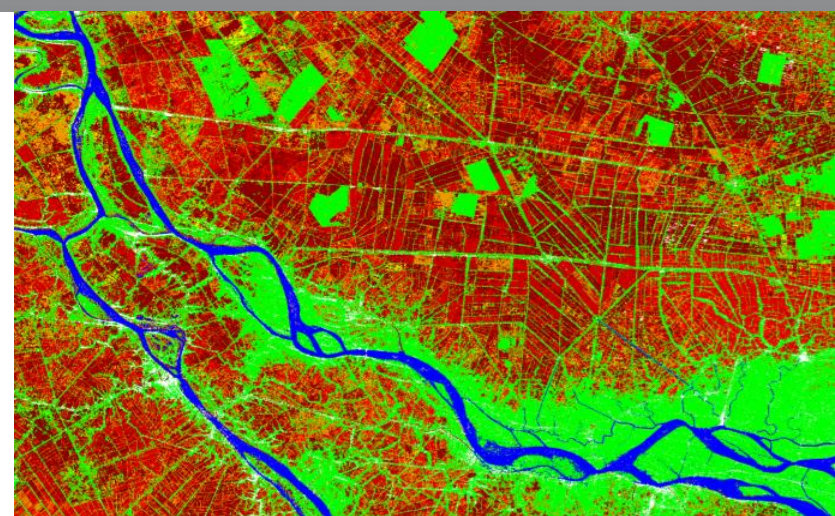
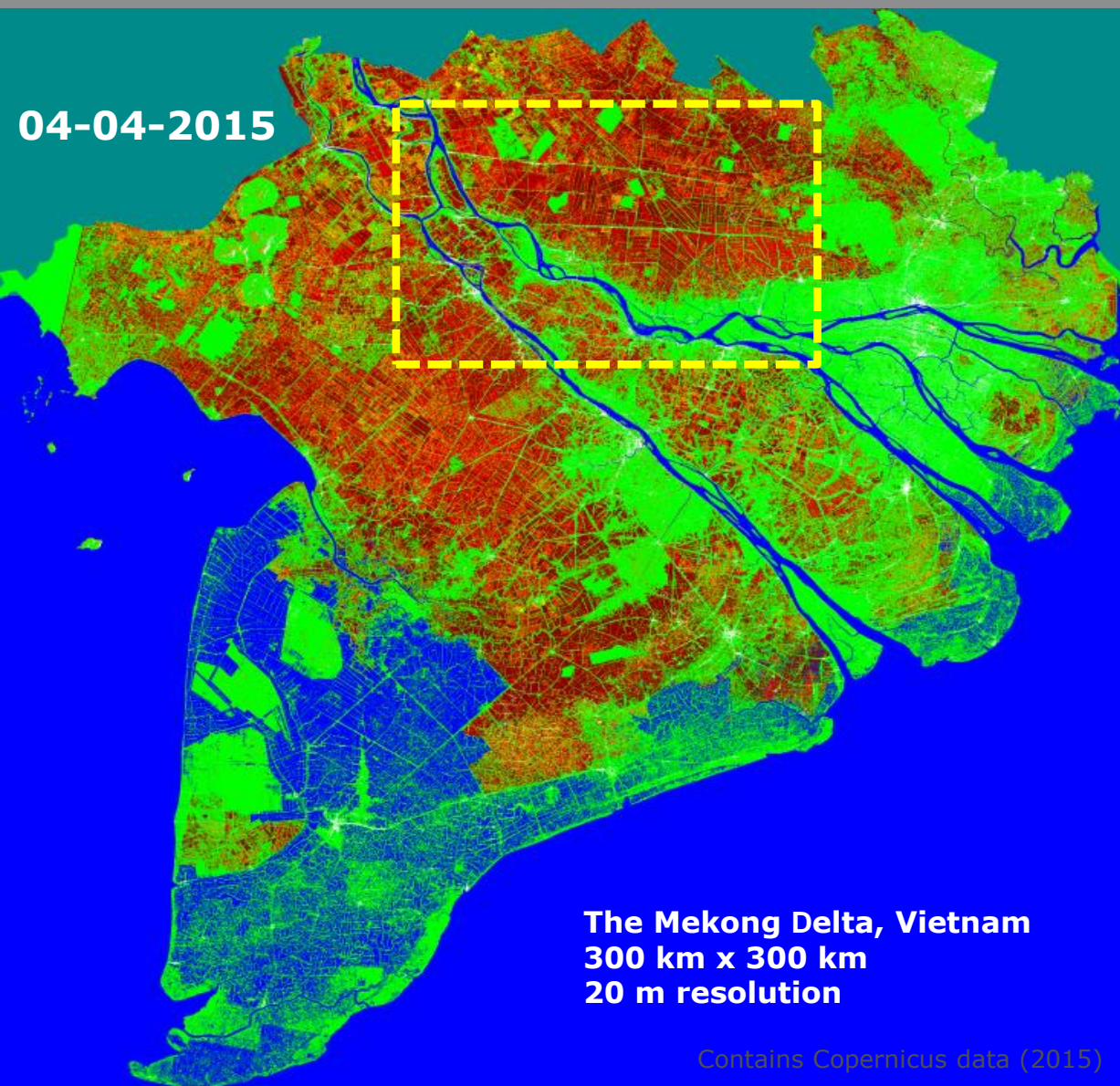
Copernicus Sentinel-1










- Launch: **3rd April 2014**, 2016, ...
- Constellation of two satellites
- C-Band Synthetic Aperture Radar, weekly coverage (2 satellites)
- Nominal lifetime in orbit of 7 years (max. 12 yrs)
- Sees through cloud cover!

Sentinel-1: Rice Monitoring

Monitoring of Crop Stages



Winter-Spring Rice

-  Rice: early stage
-  Rice: tillering stage
-  Rice: reproductive stage
-  Rice: maturity stage
-  Non rice (forest, other LULC)
-  Water (ocean, river, aquaculture)
-  Land outside the Vietnam Mekong delta

Copernicus Sentinel-3



1. Ocean and **Land Colour Instrument** (OLCI) – improved MERIS
 - 21 channels, **300 m resolution**, 1270 km swath
2. Sea and **Land Surface Temperature** Radiometer (SLSTR) – improved AATSR
 - 9 channels, 500m – 1km resolution, 1675 km swath
3. Sea & Ice Topography Payload (SRAL, MWR, GNSS, DORIS, LRR)



- Launch: end 2015 & 17, ...
- Revisit at equator = **2 days (or daily with 2 satellites)**

Copernicus Sentinel-2



Multispectral High Resolution Optical Imager

- Launch: **June 23rd 2015**, 2016, ...
- 13 bands (VIS, NIR & SWIR)
- 290 km swath at 10, 20 and 60 m
- Systematic acq. of all land and coasts
- 5 days repeat cycle with 2 satellites
- 7 years design lifetime (max. 12 yrs)



Sentinel-2 Swath & resolution

10 m for field scale mapping



10 meters resolution



290 km

European Space Agency

Copernicus data (2015)

SENTINEL-2: 5 days revisit for crop dynamics

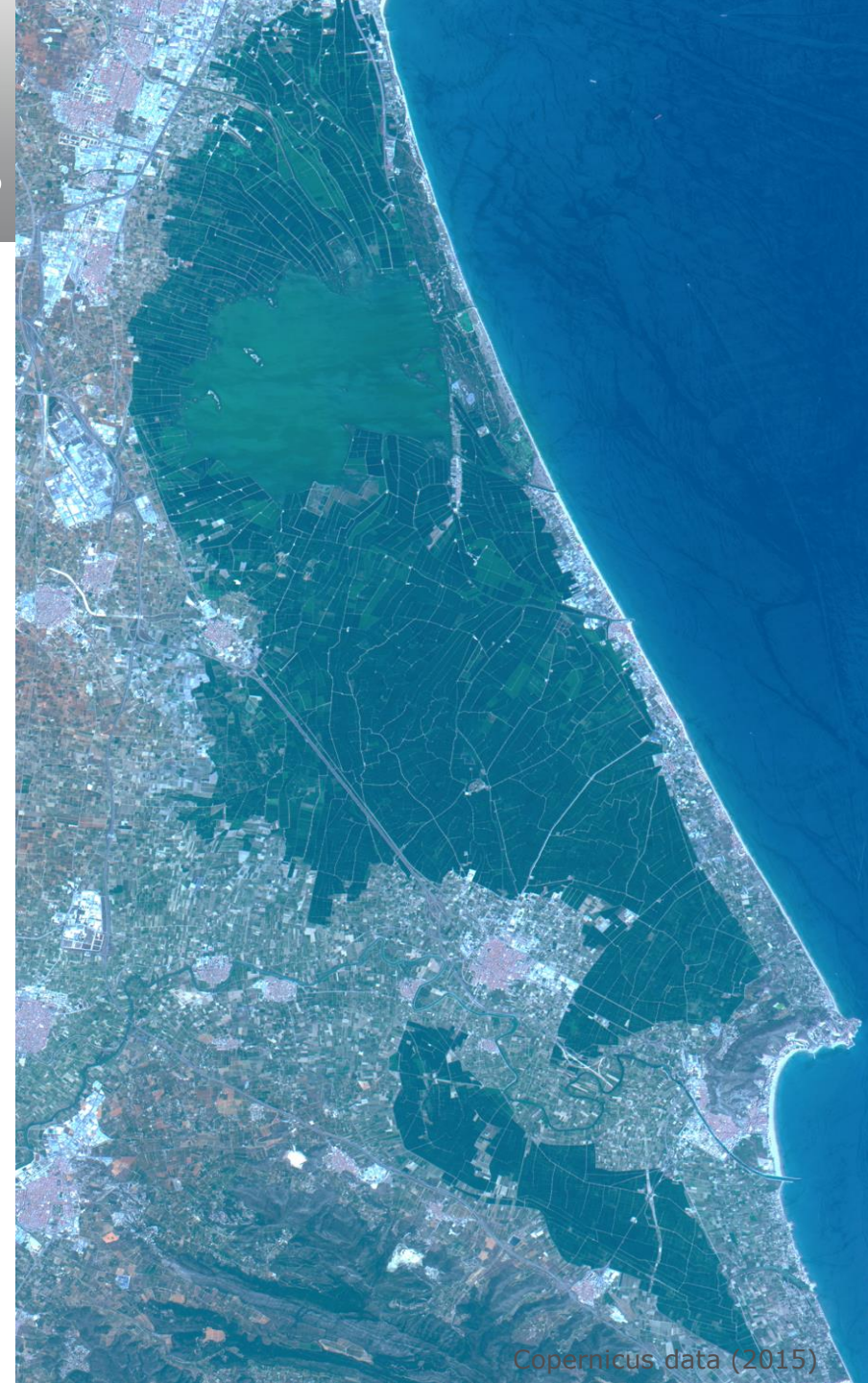
Sentinel-2 (2 satellites) 5 days revisit frequency (SPOT5-Take5)

Valencia (Spain) – April – June 2015

flooding dynamic of rice field and monitoring the
start of growing season

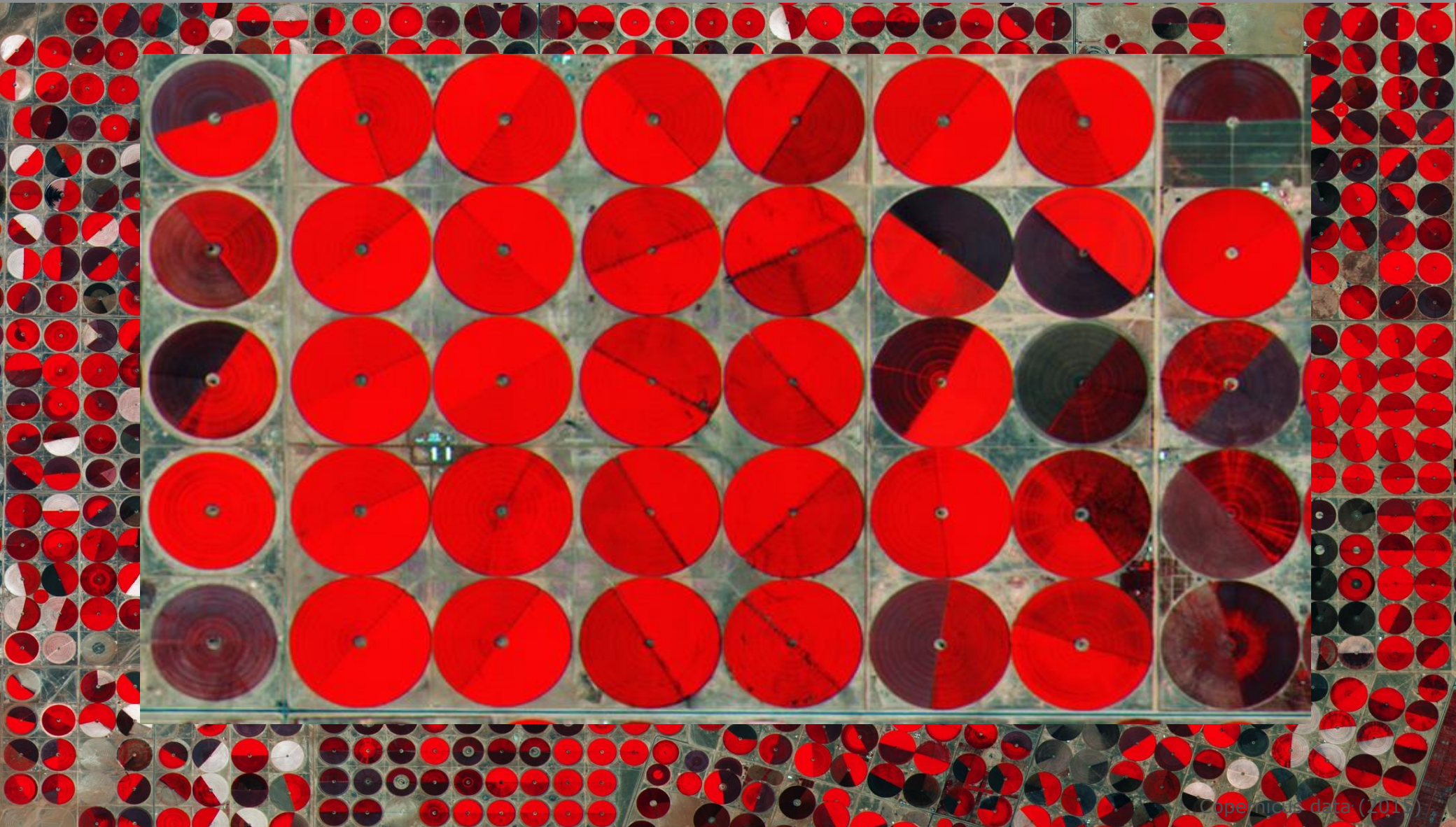
20 April 2015
30 April 2015
10 May 2015
15 May 2015
20 May 2015
25 May 2015
04 June 2015
09 June 2015
14 June 2015
19 June 2015

16 July 2015 by Sentinel-2a



Copernicus data (2015)

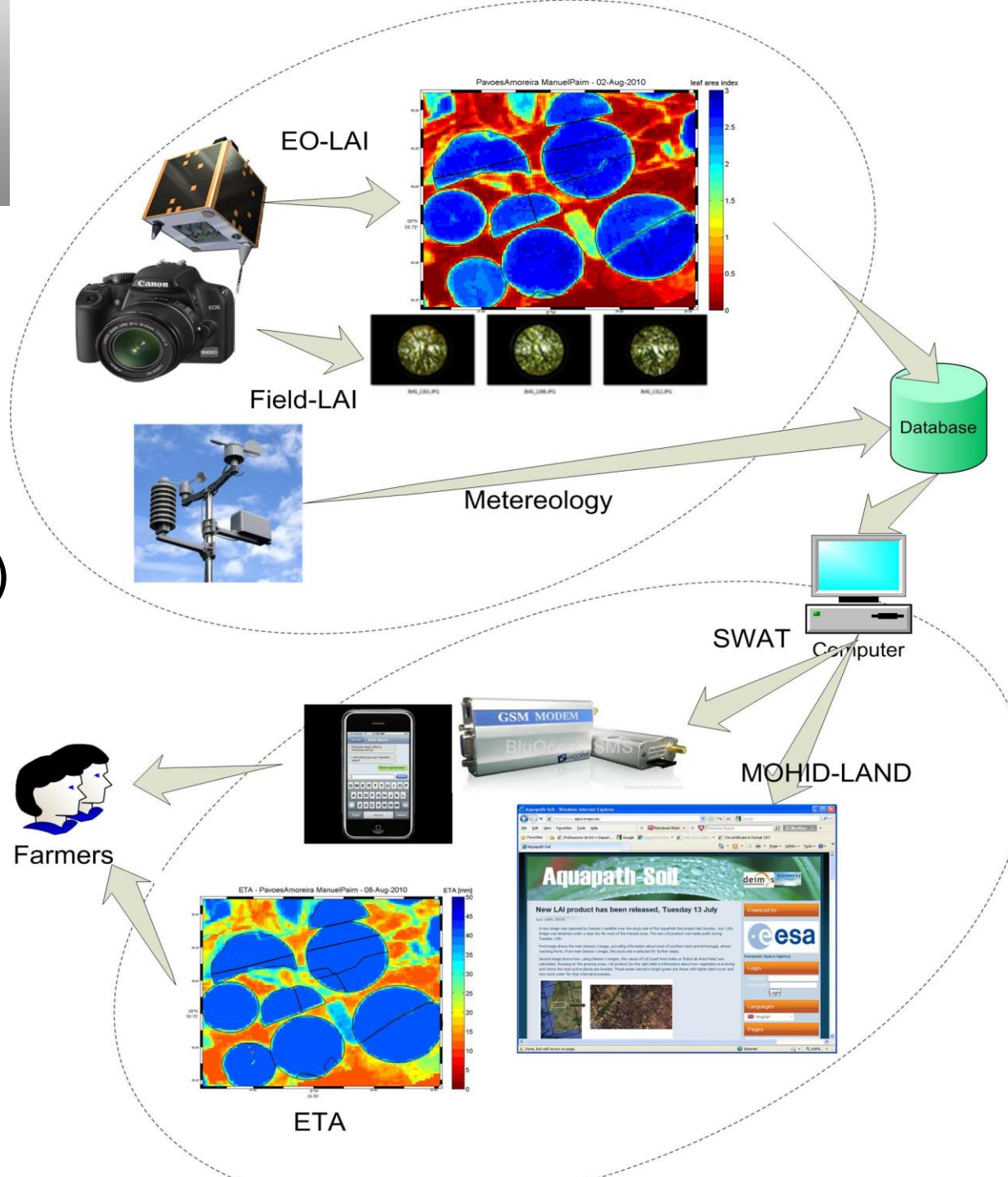
SENTINEL-2: Irrigation monitoring



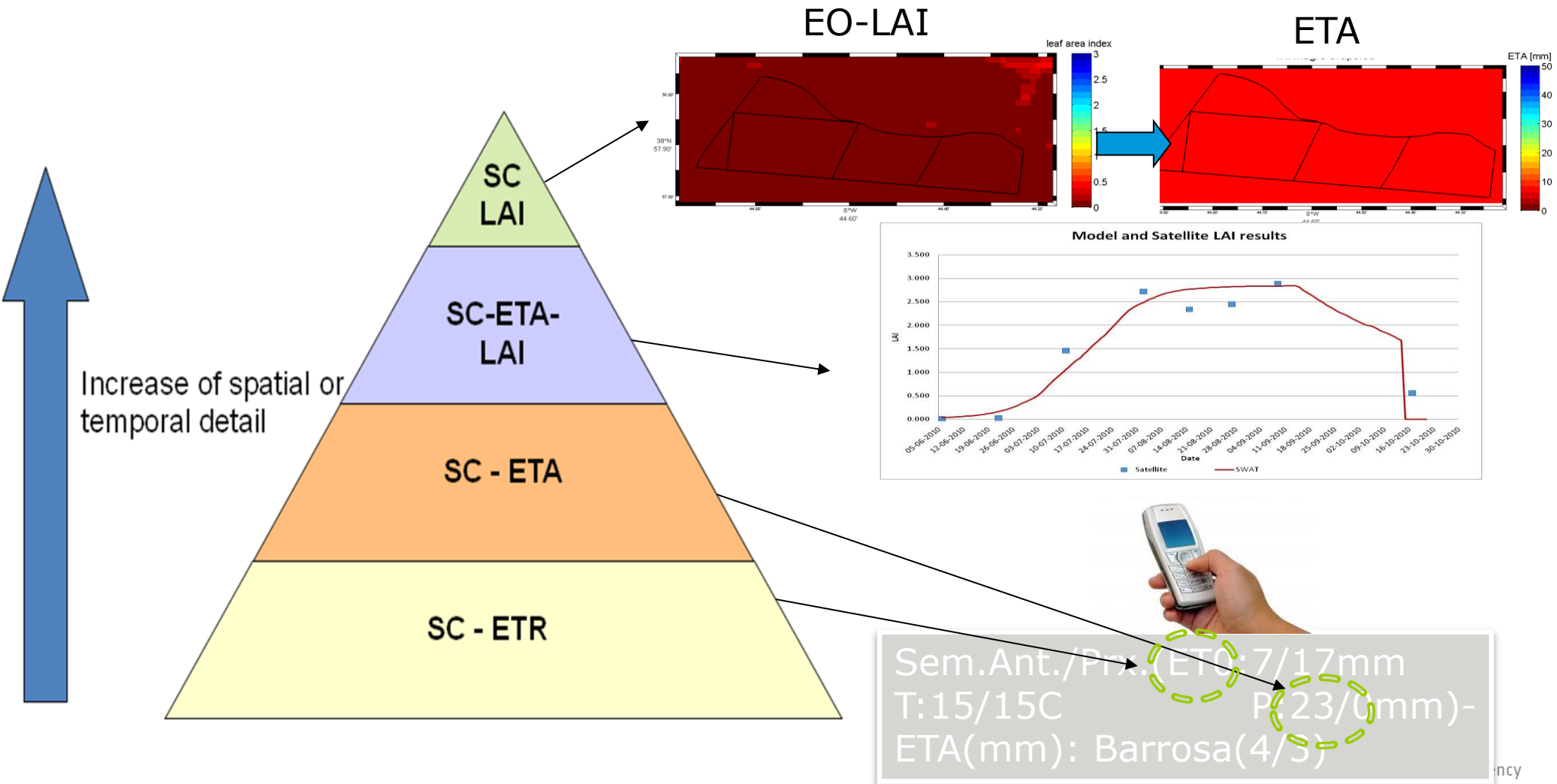
Aquapath-Soil

Irrigation decision support service:

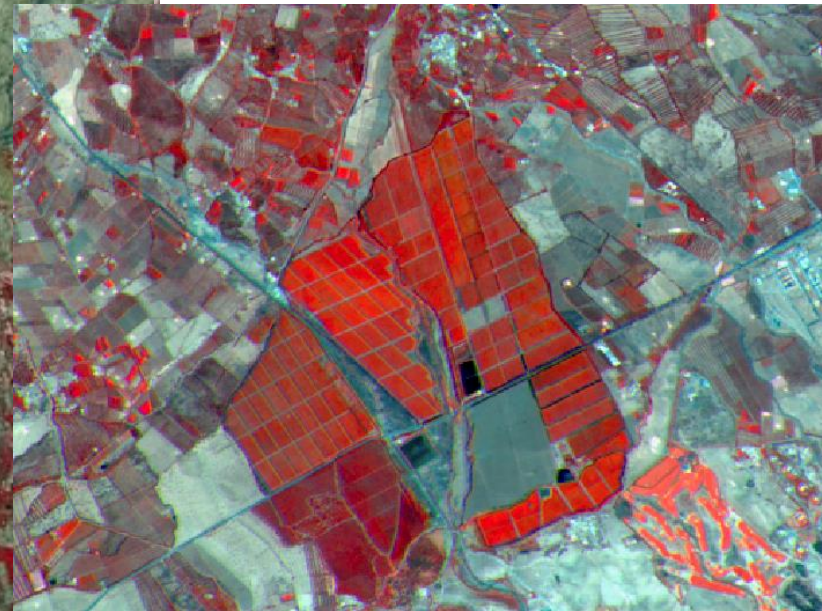
- Estimation of Evapotranspiration (ETA)
 - Spatial explicit LAI
 - Meteorology
- Delivery to farmers
 - SMS and maps publication



Aquapath-Soil: Irrigation Information Services



Sentinel-2: Irrigation monitoring in Morocco



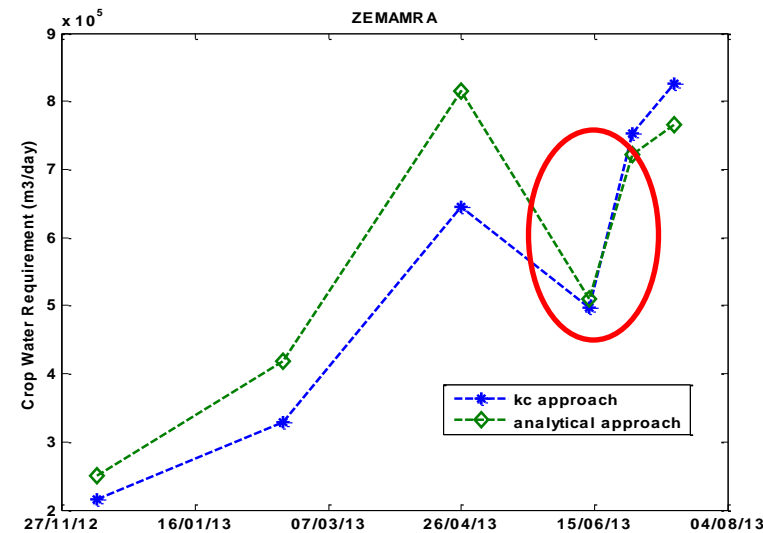
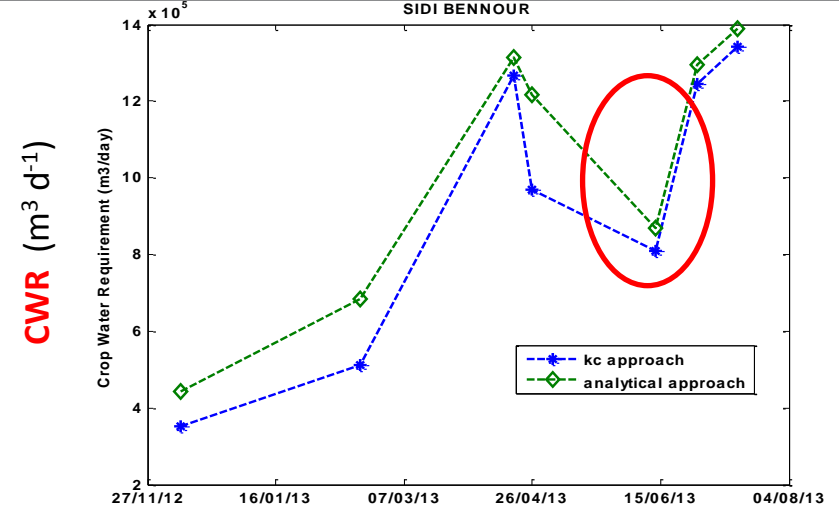
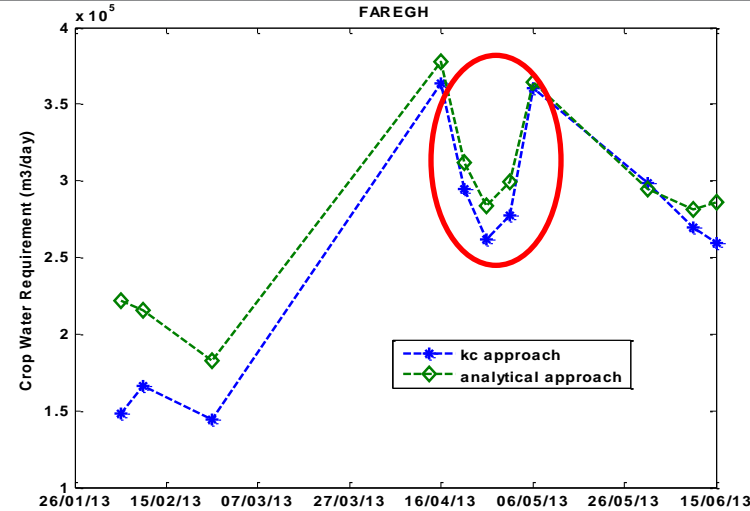
Copernicus data (2015)



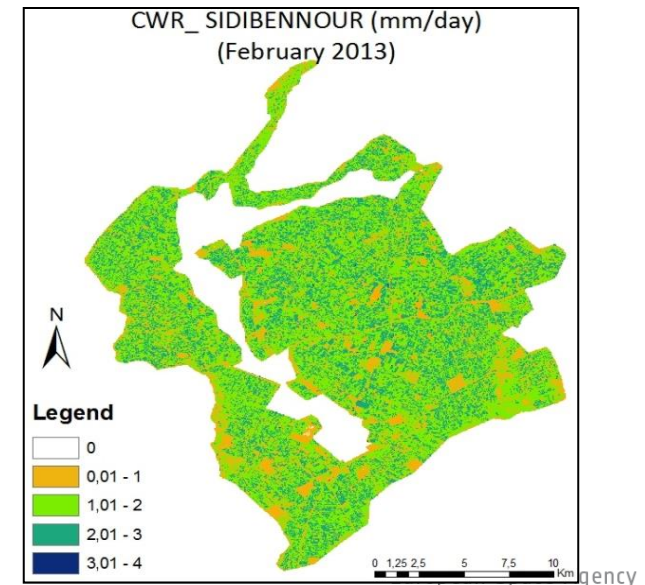
European Space Agency

Crop water requirements over time

Irrigation performance in Morocco



Dip in June indicates the transition from winter (sugarbeet) to summer (maize) crops



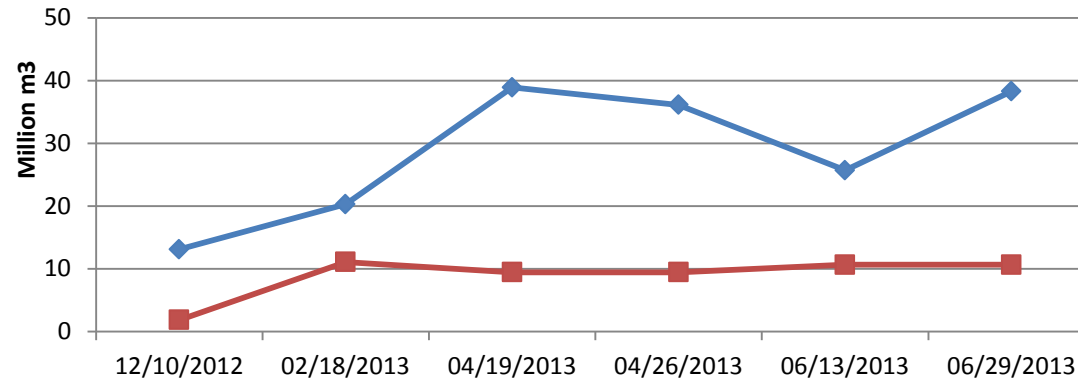
Total crop water requirements for the three irrigation schemes

Crop Water Requirements vs Water Allocation

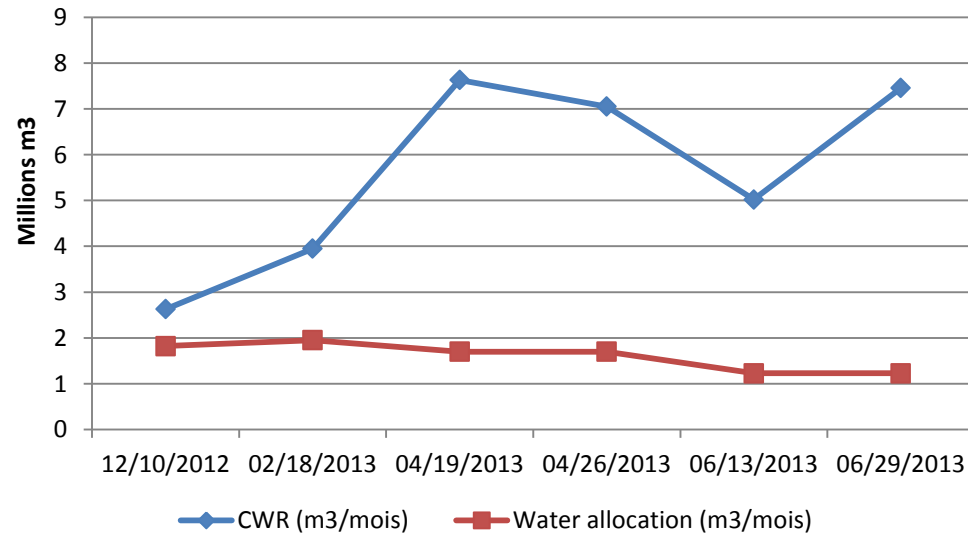
For different Irrigation Schemes



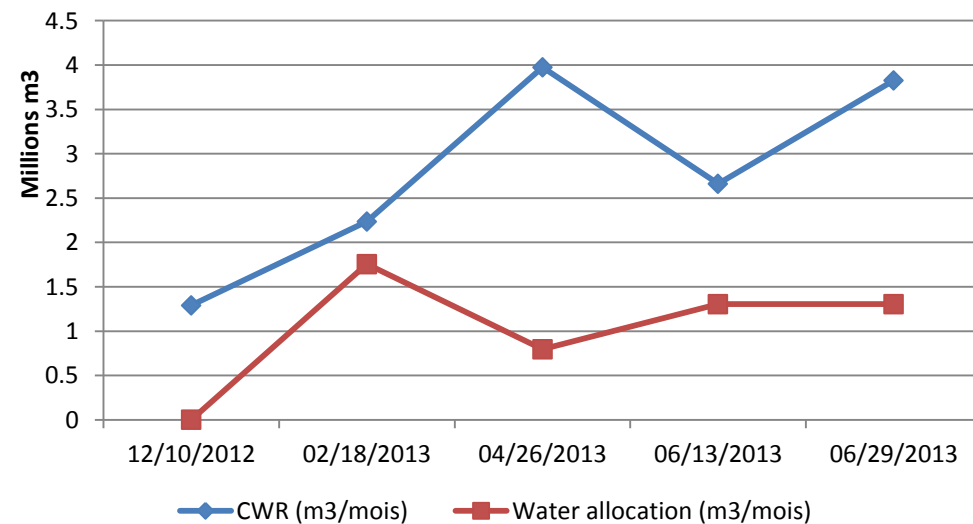
CWR Vs Water allocation
District of Sidi Bennour



CWR vs Water allocation
CGR 330 - GRAVITY



CWR Vs water allocation
CGR 322 - SPRINKLER

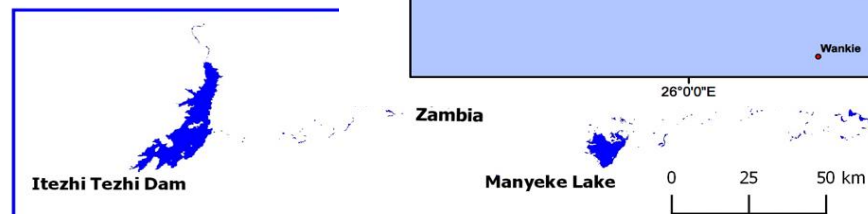
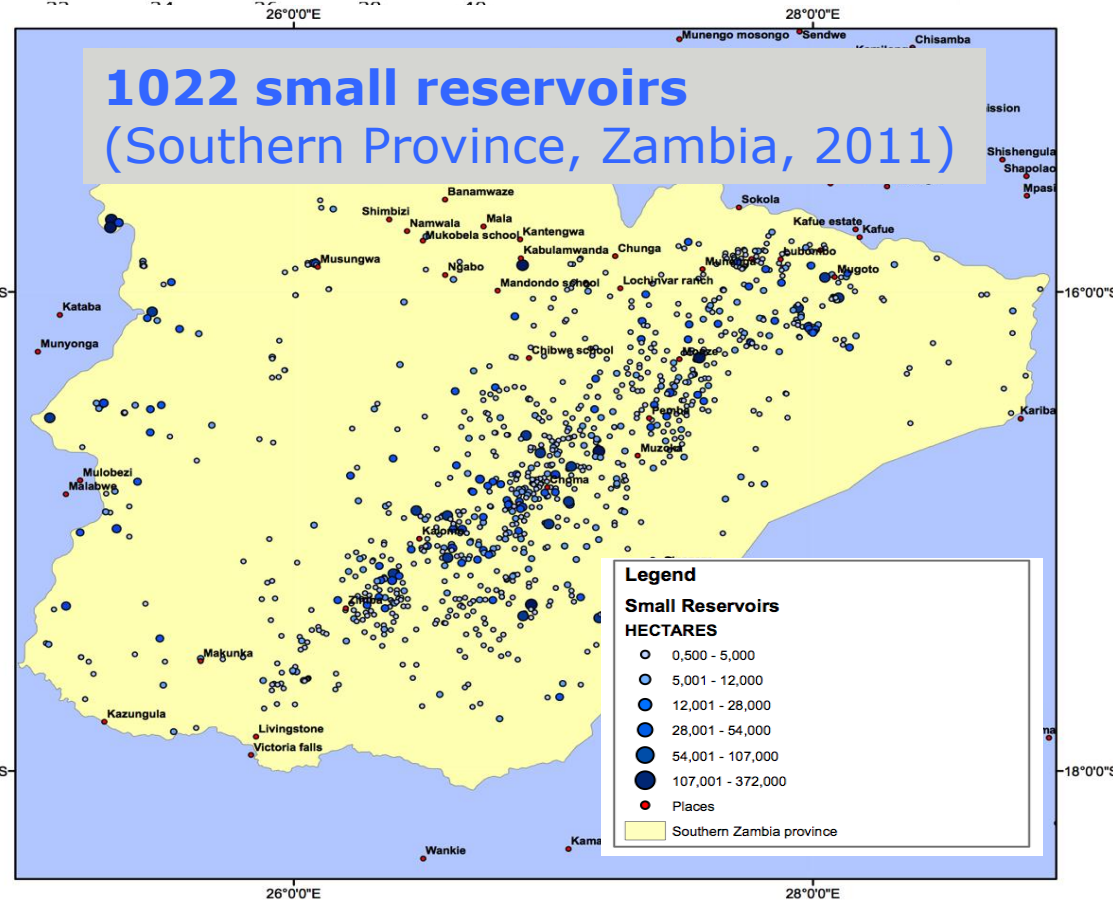
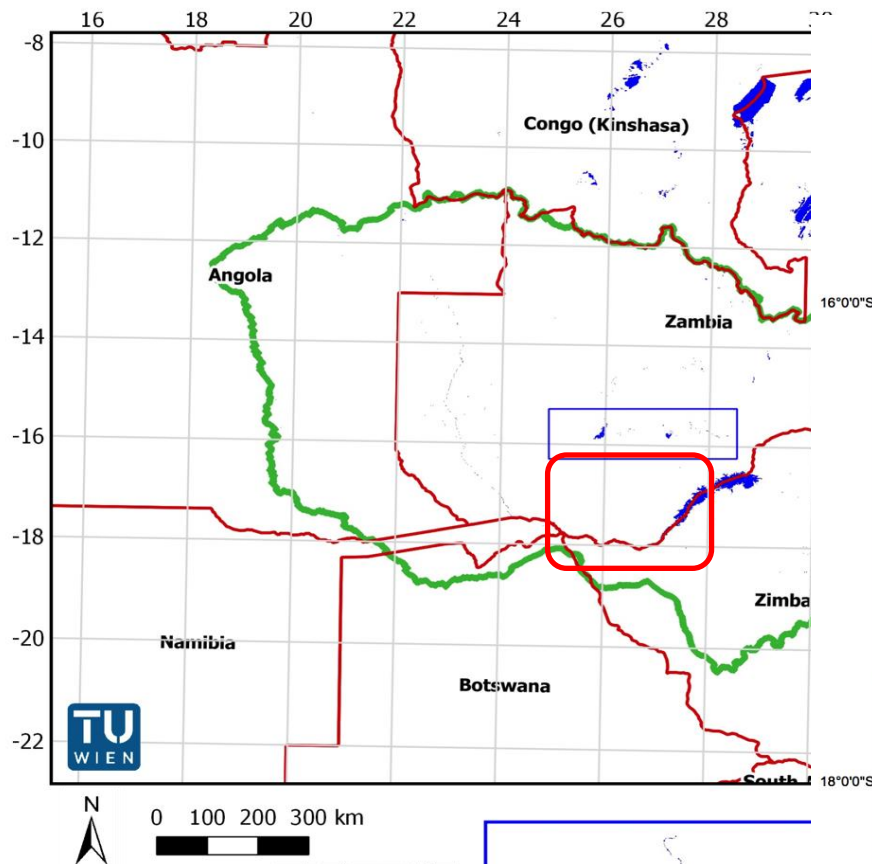


Water Bodies Mapping

Irrigation & Dam planning



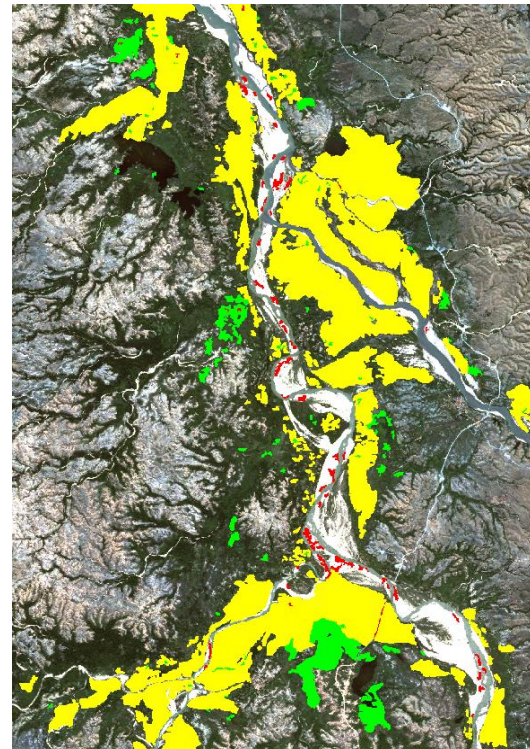
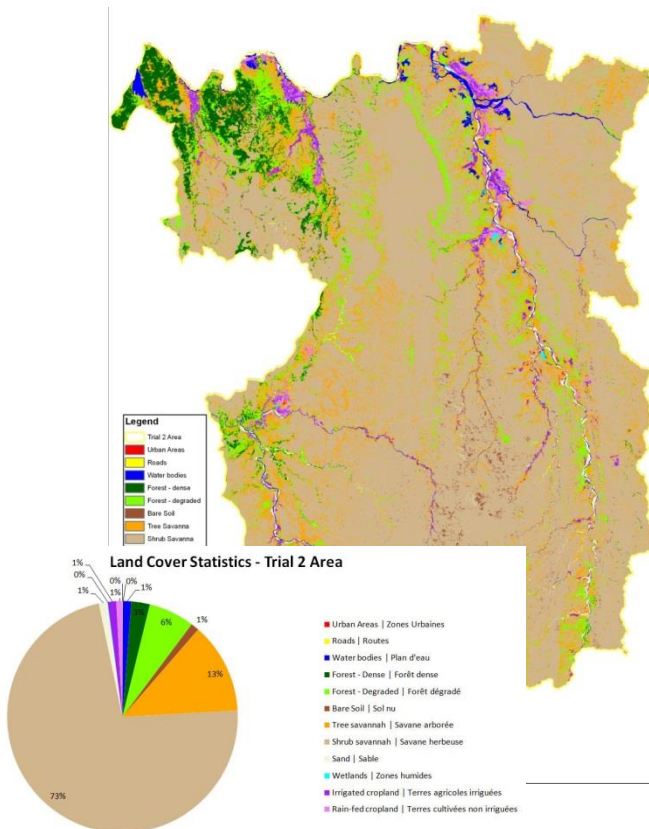
Permanent Water Bodies, Zambezi River Basin, Africa



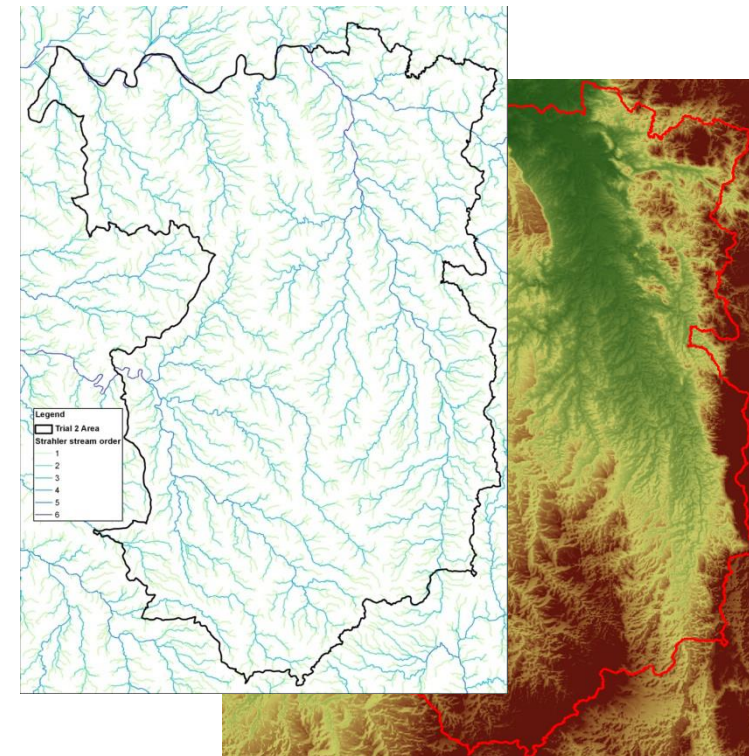
Irrigation Infrastructure Planning in Madagascar



EO service support the planning of UN-IFAD (International Fund for Agricultural Development) investments in irrigation schemes



Potential areas for irrigation schemes (in green) based on land cover, terrain and accessibility information



Conclusions: Sentinels Potential for Agriculture



Operational Observations from the Sentinels

- ✿ **Continuous information from field to global scale**
- ✿ **Responding to most GEOGLAM target products**
- ✿ **Open data policy & long-term continuity for sustainable uptake**



Supporting activities needed for full exploitation

- ✿ **Continuous R&D for optimized and validated EO products**
- ✿ **Facilitation of EO data access & multi-sensors handling**
- ✿ **Capacity Building for integration in user's operations**
- ✿ **Ongoing cooperation with Developing Agencies for Mainstreaming EO**

Sentinel-1 & -2 Data access



- Full Sentinel data access on the Science Data Hub
 - All Sentinel-1 data available since launch
 - First Sentinel-2 product samples already online!



<http://sentinel.esa.int>

▾ Welcome to Sentinel Online

Welcome to Sentinel Online, the ESA Sentinel website.

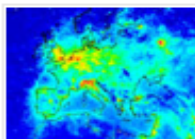
The site is constructed in such a way as to enable you to navigate easily through a variety of topics related to each Mission, Instrument, and their associated Data, as well as highlighting the Copernicus Thematic Areas served by the Missions. For more information see [About sentinel online](#).

The GMES (Global Monitoring for Environment and Security) program has been recently renamed by the European Union to 'Copernicus'. It shall be noted that currently the content of this Website refers to the terms GMES and Copernicus alongside.

▾ Sentinel Missions



▾ Sentinel Data Products



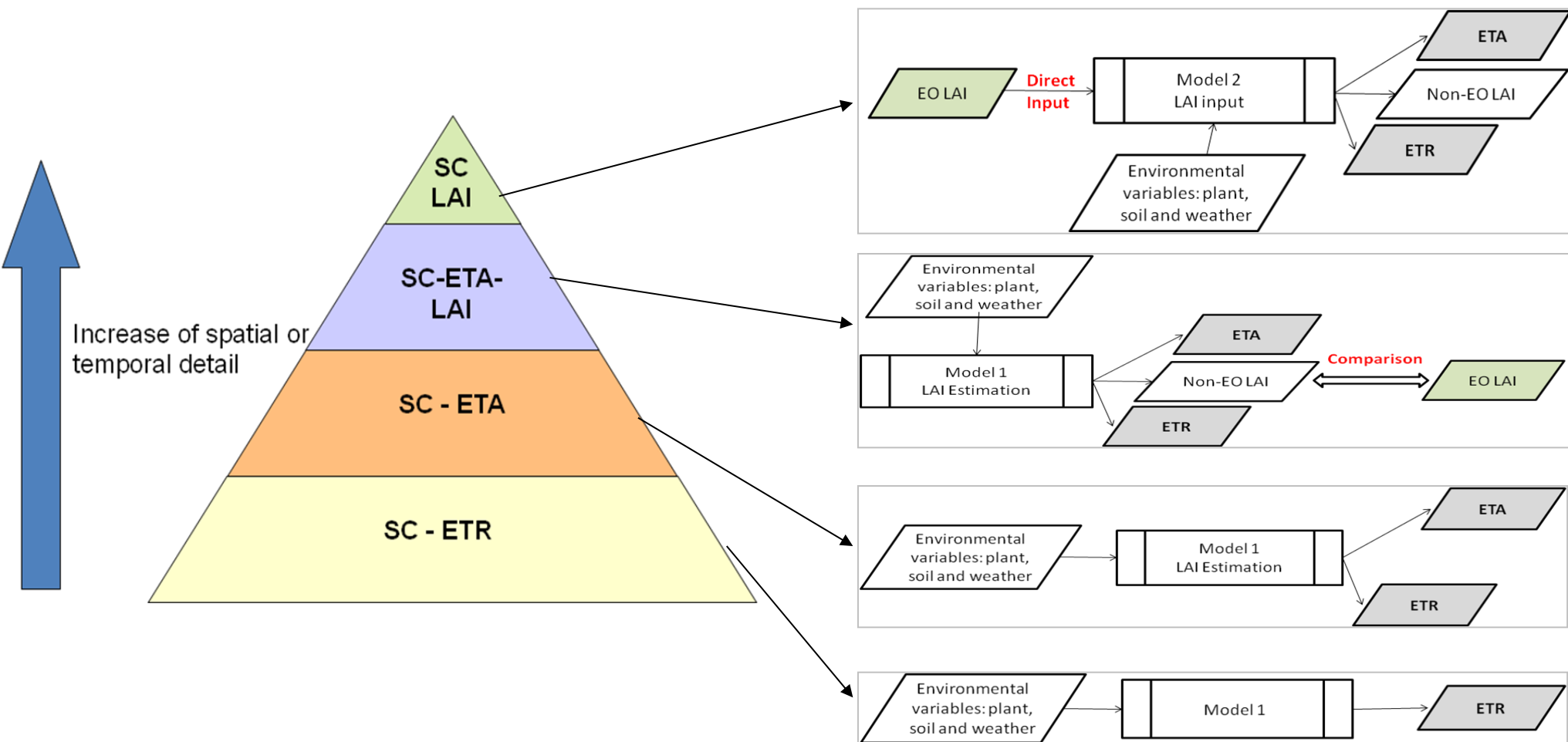
▾ Sentinel News

- [Apply for 'Sentinel-1 Student Transponders'](#)
- [Turning up the heat on Europe's first Sentinel](#)
- [Green light for GMES Copernicus](#)
- [International effort helps users get ready for](#)
- [Greece's ups and downs](#)
- [Securing operational EU funding for GMES](#)
- [ESA-NASA collaboration fosters comparable](#)

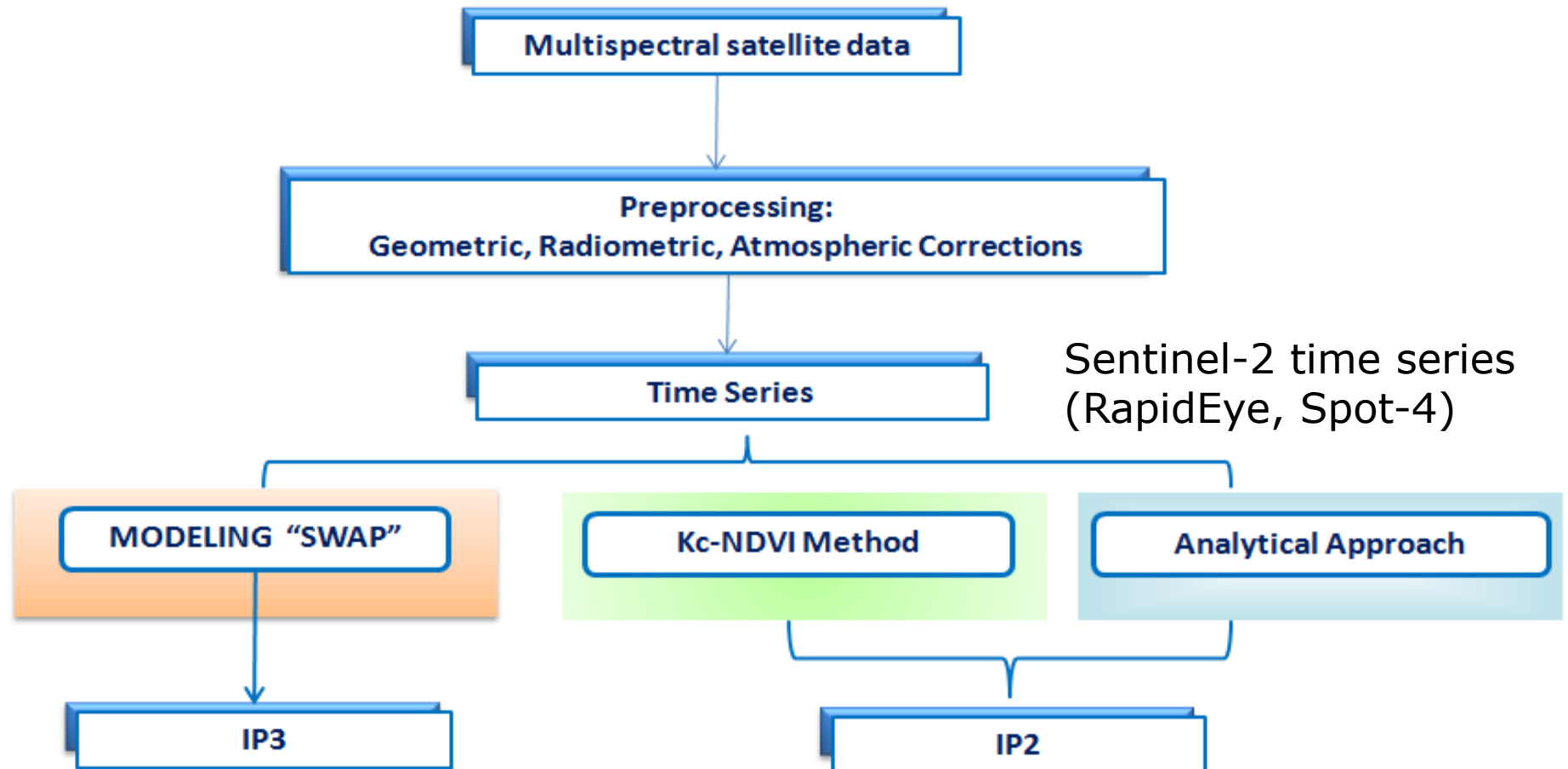
▾ Featured Image

- ▢ [Vancouver Radar Image](#)
- ▢ [ESA EO Image Gallery](#)





Estimation of Crop Water Requirements for Irrigation Performance



Multispectral satellite data

Preprocessing

1) Geometric Correction:
- Topographic map : 1/50000
- UTM, WGS 84 north, Zone 29

2) Radiometric calibration:
TOA reflectance

3) Atmospheric Correction:
TOC reflectance (Flaash model)

Multiple imaging radiometers Time Series

Layer stacking (Nearest Neighbor Resampling)

MODELING "SWAP"

Crop data

Soil data

Drainage data

Meteorological data

- Actual Evapotranspiration
- Potential Evapotranspiration
- Actual/potential Transpiration
 - Soil water content
 - Soil water pressure head

IP3

Kc-NDVI Method

NDVI

Kc

Meteo data:
Ta, RH, Rs, U,
ET0

Kc-NDVI Method:

$$ET_c(x,y) = k_c(x,y) * ET_0(x,y)$$

IP2

Analytical Approach

Net shortwave radiation R_{ns}

Albedo α

Canopy resistance $r_{c,min}$

LAI

Aerodynamic resistance r_a

h_c

Analytical Approach:

$$ET_c = \frac{1}{\lambda} \frac{\Delta(R_{ns} - R_{nl} - G) + 1013 \rho D_e / r_a}{\Delta + \gamma(1 + r_{c,min} / r_a)}$$

International Development Initiative Mainstreaming Earth Observation



- 💧 EO informing Development activities & investments
 - 💧 planning, design, implementation & monitoring
- 💧 Collaboration with International Development Banks



THE WORLD BANK



European Bank
for Reconstruction and Development



THE WORLD BANK
Working for a World Free of Poverty

English | Español | Français | العربية | Русский | 中文

GO

ABOUT DATA RESEARCH LEARNING NEWS PROJECTS & OPERATIONS PUBLICATIONS COUNTRIES TOPICS

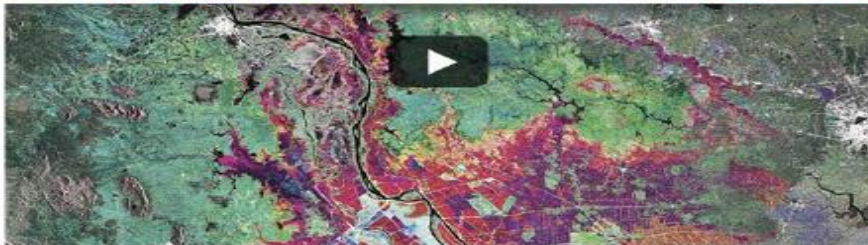


TECHNOLOGY

Satellite Data Informs Development

A World Bank Group partnership with the European Space Agency is using satellites to gather a wide variety of information about climate change, water quality, coastal erosion, flooding, urban growth, and more. It has been particularly useful in conflict zones, where data can be difficult to gather.

► [Satellite Success Stories](#) | [Website](#)



Satellite Data for Development



Innovation in Poland



Getting Water on Tap



Fund for the Poorest

RE SOURCES

Civil Society | Governments | Businesses | Investors | Job Seekers | Journalists | Students

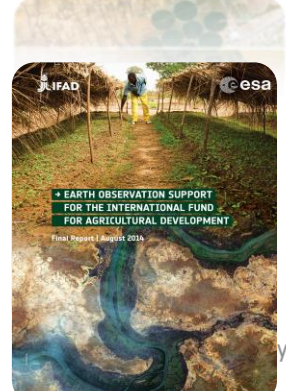
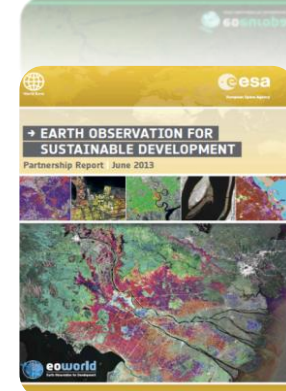
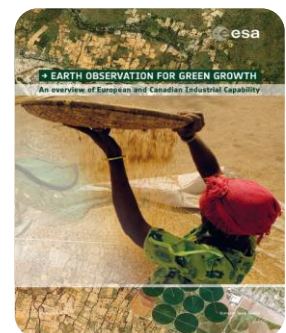
WHAT'S NEW

RELEASE

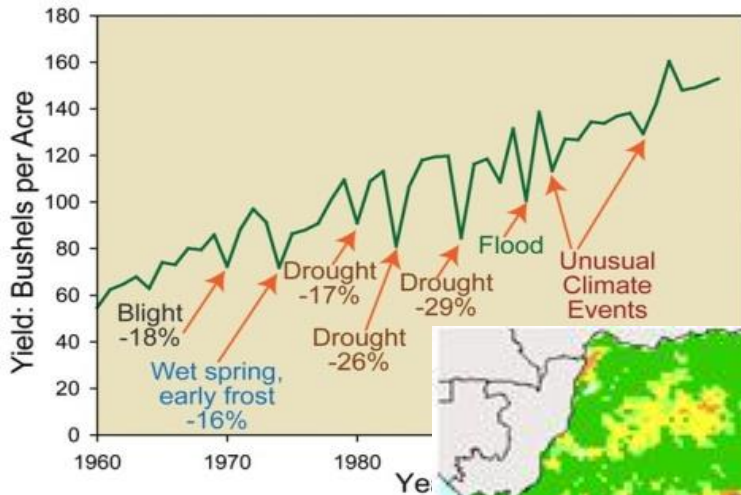
BLOGS

When Vehicle Safety Matters

2013 Annual
Meetings



SMOS: Soil moisture for drought



SMOS data used to predict drought and improve crop yield by US Department of Agriculture (USDA)

Crop

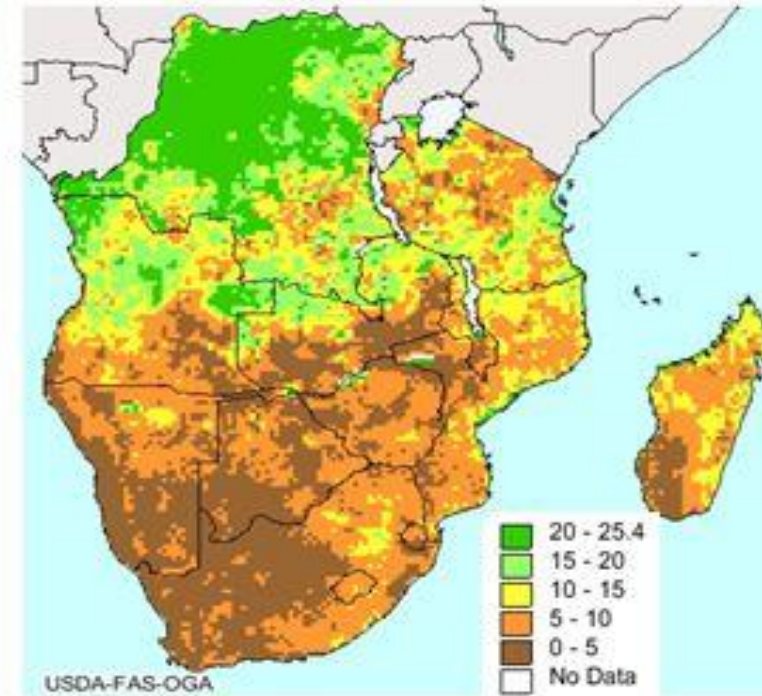
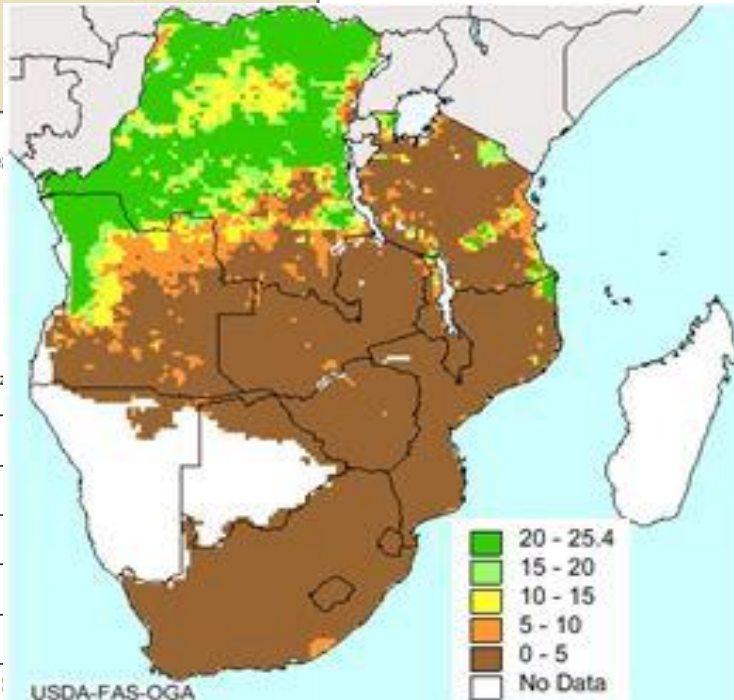
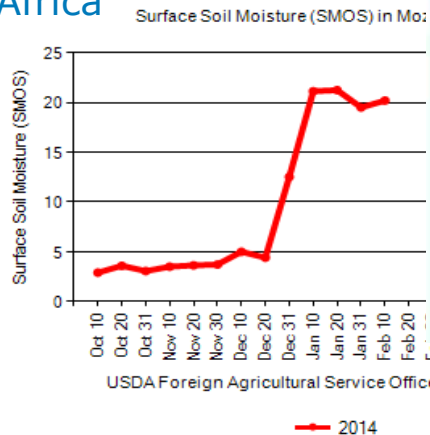
Explorer

website:

<http://www.pecad.fas.usda.gov/cropexplorer/>

Credit: USDA FAS

Current Zambezi Flood Africa



European Space Agency

Credit: USDA FAS, Soil moisture in southern Africa in mid-April 2014.

Metop/ASCAT: Soil moisture for crop growth



„Traffic light“ system – Near Real Time Start of Season assessment

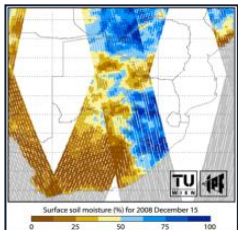
Soil is moist enough or...



...not moist enough...

...for the Start of Season (SoS)

Soil Water Index (based on ASCAT)



Processing Chain

